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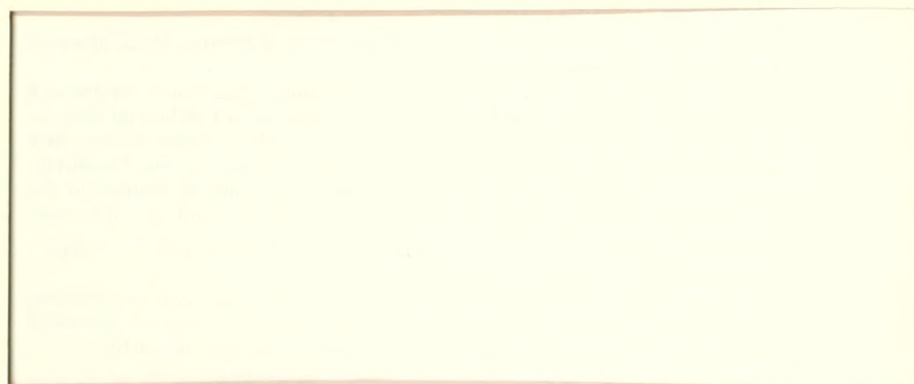
ORGANIZATIONAL FACTORS IN  
PROJECT PERFORMANCE

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August 1965

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Presented at the Second Conference on Research Program Effectiveness, sponsored by the Office of Naval Research, Washington, D.C., July 25, 1965. The research has been supported by a grant (NsG 235) from the National Aeronautics and Space Administration.



## Introduction

A project, carried out by a company under contract with a government agency, has many advantages as a unit of study in the investigation of effective performance of research and development. Such a project has a defined beginning and end, it has initial cost and schedule estimates as well as a work statement of technical requirements, and it has separate and audited financial accounting.

The traditional organization of industrial work by functional departments is often modified to form temporary special task-forces made up of people from several different functions devoted to a clearly defined objective. Such groups are integrated into the total organization in various ways: some are strictly "staff", others have complete "line" authority, and many fall somewhere between the two extremes, or the information is ambiguous.

The vices and virtues of project organization for research and development have been described and debated by many during the past decade (see e.g., Baumgartner, 1963; Gaddis, 1959; Janger, 1963; Kelton, 1962). Defense and space agencies often require industrial contractors to adopt a project form of organization and they have issued manuals of guidance such as the Air Force Systems Command Series 375. Although individual cases of successful and unsuccessful projects have been described (e.g., Kast and Rosenzweig, 1963), there exists no systematic comparison of the effectiveness of different forms of project organization. This report will describe the varieties of organization found in a typical sample of 37 large projects, and analyze the relation to performance effectiveness.





## Research Methods

This report presents only a fraction of the data collected during the past three years in a broad study of project management\*. Projects were selected on the basis of three criteria:

1. All were R & D contracts awarded by a government agency (or industry prime in several cases) to an industrial firm.
2. All were over \$1 million in total value (excluding any follow-on production work).
3. All were very recently completed or rapidly nearing completion.

Projects were located in two ways. Alternate firms in the list of 100 largest defense and space firms were invited to cooperate, and if they were willing, a division laboratory was randomly selected, and its most recently completed (or terminated) project became the target of study. The other source was a government contracting agency, in which one or more projects were chosen randomly from those most recently completed.

Information on each project was obtained from five sources: the laboratory manager (LM), the project manager (PM), the government technical monitor (GTM), the government contract administrator (GCA), and the company contract administrator (CA). Judgments of successful performance and a statement of their criteria for evaluating successful performance were obtained from the first four. The laboratory and project manager described the organization and operations of the project

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\* Participating in this investigation as research associates and assistants have been J. Randall Brown, Michael M. Gold, Arthur J. Hansen, Kenneth R. Hootnick, Richard B. Maffei, James E. Mahoney, Robert L. Pearson, Jean-Paul Richard, and Irwin M. Rubin.



group. They and the technical monitor also described the critical problems which occurred during the course of the project, and provided measures of success such as meeting technical performance requirements, schedule deadlines and cost criteria. Administrative performance was described by the contract administrators in both the company and the government agency. Inevitable difficulties in securing some of the desired information resulted in incomplete records in several cases. Of the 37 projects, 22 are complete (LM, CA, PM, GTM, and GCA), 8 are presently missing the GTM, and 14 are missing the GCA.

The questionnaires used in this study were developed on the basis of published literature and of interviews with experienced research managers. Valuable use was made of the extensive report by Peck and Scherer (1962) and a study by Osborne (1962) in which he identified critical factors in project performance from interviews in industrial and government R & D organizations and from his experience as manager of the Boresight program for RCA. The research instruments were pre-tested on approximately 20 projects, and analysis of these responses led to extensive revisions.

#### Description of Projects

The 37 projects were funded by 12 government agencies--five in the Air Force, two in the Navy, two in the Army, two in NASA and one in another civilian agency. The 32 firms performing the projects are large corporations in the aerospace and electronics industries; 26 are among the 100 largest performers of government-funded R & D. Five more are smaller but in the same technology. The other one is a large corporation in a basic industry.





The laboratories or engineering facilities in which the projects were performed are located in all regions of the country. Four are in the New England region, 13 in the Middle Atlantic, six in the South and Southwest, four in the Middle West and ten in the West Coast.

The laboratories are primarily engaged in government R & D work, with 23 of them reporting that more than 90 percent of their work was on government contracts, and only two reporting less than 40 percent on government R & D.

The projects ranged in size from \$1 million to \$60 million with a median of \$4 million. The average project duration was 3.4 years and none lasted more than 6 years. Almost all of the projects required advances in the "state of the art" in a technological field such as advanced radar systems, microminiaturization of electronic modules, electronic data processing interfaces with telemetry systems, etc.

The contractual end products of the R & D projects were, in two cases, final design and in all others were hardware items (prototype, initial operational hardware, or in five cases, a few production items).

The nature of the end products and the technological fields makes it clear that the projects are more developmental than fundamental research. The project manager and the technical monitor were asked to estimate for each project how much of the total effort was in each type of research and development (Table I).

#### Definition of Success

One of the objectives of this study is to determine what is considered success in the performance of R & D projects. The LM, PM, GTM, and GCA on each project were asked "What are your criteria of success?"



TABLE I

Effort Allocation in Projects  
(Average of estimates by Project Managers and Technical Monitors)

| <u>R &amp; D Classification</u>       | <u>Per cent of total project effort</u> |      |        |
|---------------------------------------|---|------|--------|
|                                       | Range                                   | Mean | Median |
| Basic Research                        | 0-20%                                   | 2%   | 0      |
| Applied Research                      | 0-50%                                   | 15%  | 15%    |
| Advanced Development                  | 0-90%                                   | 41%  | 40%    |
| Refinement, Testing<br>and Evaluation | 0-97%                                   | 41%  | 40%    |





Please rank them in order of importance." The responses are shown in Table II and Fig. 1.

Technical performance is by far the most important consideration, being ranked first by 63% of the company respondents, and 97% of government respondents. Meeting delivery schedules is a poor second with achievement of target costs third in importance. Almost all the projects were performed under some form of cost-plus contract.

The significant ranking of customer satisfaction in the list of criteria valued by company respondents probably reflects a recognition of the fact that the customer is judging performance with the same criteria as the contractor. It is doubtful that the low rank of profit and follow-on business as criteria of success reflects a lack of interest in these factors. Rather, the company respondents probably recognize that these benefits will follow if the three major criteria are met.

#### Measures of Project Performance

The major objective of this report is to relate the form of project organization to performance ratings for each project. Three measures of performance are used: cost overruns, schedule overruns, and a combined success rating.

Performance to schedule and cost targets is more easily measured than technical performance and is also directly comparable across the full spectrum of technological endeavors. The occurrence (or nonoccurrence) of cost and schedule overruns is used as an objective success



TABLE II

**Criteria Used in Evaluation of R & D  
Projects by Contractors and Customer Agencies**

|                              | Laboratory Manager |     |    | Project Manager |    |    |
|------------------------------|--------------------|-----|----|-----------------|----|----|
|                              | Rank               |     |    | Rank            |    |    |
|                              | 1                  | 2   | 3  | 1               | 2  | 3  |
| Technical Performance        | 63%                | 10% | 9% | 63%             | 9% | 7% |
| Meeting Schedule             | 8                  | 31  | 22 | 7               | 34 | 30 |
| Meeting Target Cost          | 3                  | 24  | 22 | 5               | 22 | 37 |
| Customer Satisfaction        | 11                 | 21  | 9  | 15              | 13 | 3  |
| Profit                       | 6                  | 7   | 13 | 2               | 9  | 0  |
| Follow-on Business           | 6                  | 0   | 17 | 2               | 6  | 13 |
| Company Prestige             | 3                  | 3   | 4  | 5               | 6  | 3  |
| Develop Technical Capability | 0                  | 3   | 4  | 0               | 0  | 7  |
| Commercial Applications      | 0                  | 0   | 0  | 0               | 0  | 0  |

|                       | Government<br>Technical Monitor |    |    | Government<br>Contract Administrator |     |    |
|-----------------------|---------------------------------|----|----|--------------------------------------|-----|----|
|                       | Rank                            |    |    | Rank                                 |     |    |
|                       | 1                               | 2  | 3  | 1                                    | 2   | 3  |
| Technical Performance | 100%                            | 0% | 0% | 94%                                  | 11% | 0% |
| Meeting Schedule      | 0                               | 60 | 50 | 0                                    | 33  | 60 |
| Meeting Target Cost   | 0                               | 40 | 50 | 6                                    | 56  | 40 |





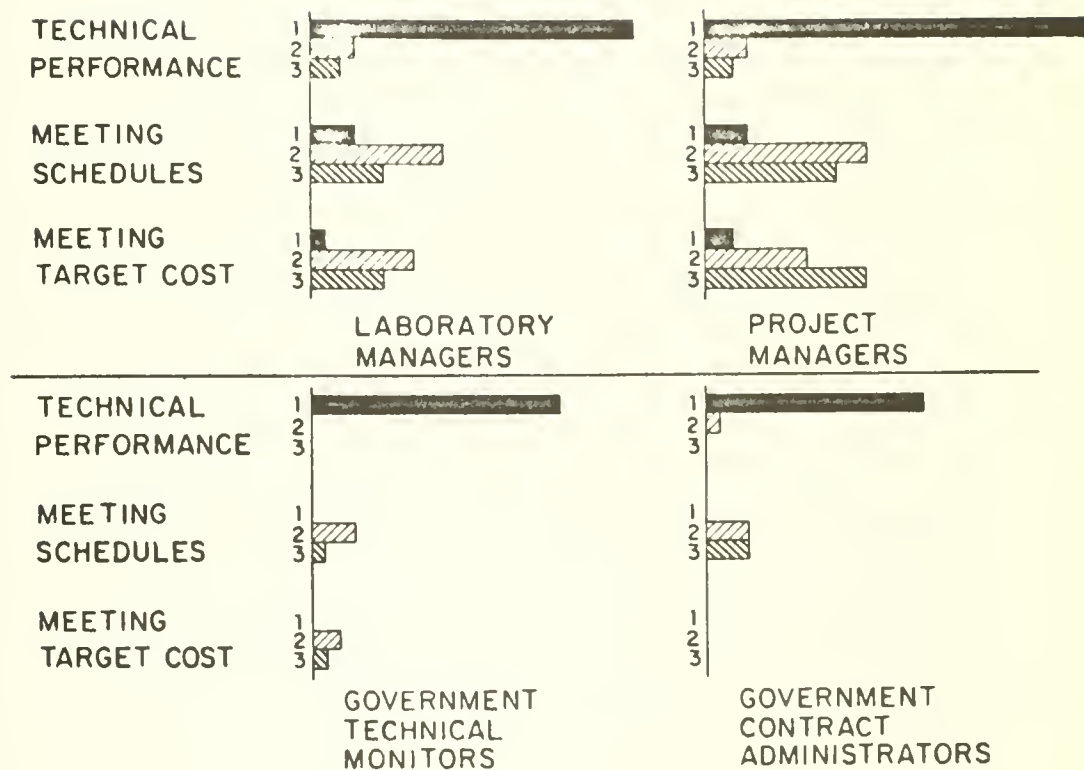


FIG. 1 RANKING OF FACTORS USED IN EVALUATION OF R&D PROJECTS BY CONTRACTORS AND CUSTOMER AGENCIES



measure in this study. Information on cost and schedule changes was gathered from the project manager and contract administrator in the company and from the government contract administrator. Careful cross-checking on the reasons for contract changes made it possible to eliminate those caused by a customer's action, such as a change in scope or specifications, or the unavailability of government test equipment or facilities. Thus only those slippages which were directly attributable to the actions of the contractor firm are included. While the data do not at present include the amount of cost and schedule variances, only those greater than 10 per cent are included. On this basis there were 28 cost overruns, 6 on target, and 3 underruns. In schedule performance there were 28 projects with schedule overruns, 8 on target, and 1 under-run. These results are not unlike those reported by Marshall and Meckling (1962), and Peck and Scherer (1962). The rank correlation between cost and schedule performance was 0.82, so the two are combined to form a single performance measure.

It is presently impossible to compare the technical performance of different projects by any objective measures. In one instance, speed may be the primary technical objective of a system (missile, airplane, etc.), while in another case range is most critical. In an electronics system reliability or maintainability may be the chief goal. Consequently the measures of successful technical performance used in this study are expert judgments by the most fully informed individuals (cf. Peck and Scherer, 1962).





Success ratings were obtained independently from the project manager, the laboratory manager, the government contract administrator and the technical monitor. The ratings are on a scale from one to nine, with one representing an outstanding success and nine signifying a failure (in some relative sense, since no project in this study achieved the absolute failure of being cancelled before completion). All except one of the ratings fell in the range of one to five, within which there was a symmetrical distribution with the mode at three.

The intercorrelations of ratings made by the four different kinds of experts are shown in Table III. As might reasonably be expected, the government technical monitor shows the highest average agreement with the others. Because he has the technical expertise and the intimate association with the project required for a valid judgment, while also possessing a critical attitude from his position as buyer, his rating is taken as the criterion of successful performance. For 11 of the projects, the technical monitor's rating has not been obtained. In these cases the score was determined by weighting the project manager's rating.\*

The success rating by the government technical monitor must be interpreted as technical success, rather than cost and schedule performance. When asked to rank their criteria for evaluating a project as successful or not, all the technical monitors gave first rank to technical performance (Table II). Indeed, the correlation between success rating and cost and schedule performance is low and not significant. For these projects the two measures may be considered independent.

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\* The regression computed on the 26 complete sets of ratings is Technical monitor rating =  $1.5 + 0.70$  project manager's rating.



TABLE III  
Spearman Rank Correlation Coefficients  
of Success Measures

| Rating by                    | Project<br>manager | Laboratory<br>manager | Technical<br>monitor |
|------------------------------|--------------------|-----------------------|----------------------|
| Laboratory manager           | 0.60**             |                       |                      |
| Gov't technical monitor      | 0.63**             | 0.42*                 |                      |
| Gov't contract administrator | 0.28               | 0.48*                 | 0.67**               |

\* Significant at .05 level

\*\* Significant at .01 level



### Measures of Project Organization

Two measures of the form of project management have been devised on the basis of the information available. One is a measure of the authority and autonomy of the project manager; the other is the form of organizational reporting relations.

Project authority is an index of the degree of control the project manager has over all the necessary activities to accomplish his task. The more decisions that can be made within the project group, the more "projectized" the organization is. One of the primary reasons for using project organization is to provide what has come to be known as "quick reaction capability". Any decision which requires action by someone outside the project group reduces the team's ability to move fast. In this study the measure of project authority is a simple count of the number of important decisions that are made by project manager and his group.

Table IV gives a list of decision questions which were asked of the laboratory manager and project manager on each project. The authority for making these decisions would tend to reside in the project group if the organization were project oriented and in an outside functional group or higher laboratory executive if the organization were functionally oriented. For some of these decisions the authority rests with the project group in almost every case; e.g., initiation of work in support areas, and changing schedules for project subactivities. For other decisions the number of projects which do or do not have authority are approximately equal. There is no significant correlation between



TABLE IV  
Indicators of Project Authority

| <u>Decision</u>   | <u>Percent of projects<br/>in which the Project<br/>Manager has the authority</u> |
|---|---|
|   | N=37  |
| 1. Initiation of work in support areas                  | 92%   |
| 2. Change schedules for project subactivities           | 92  |
| 3. Create additional concurrent schedules               | 84  |
| 4. Assign priority of work in support areas             | 73  |
| 5. Relax performance requirements; (e.g., omit tests)   | 73  |
| 6. Authorization of total overtime budget               | 68  |
| 7. Contract change in technical scope of content        | 65  |
| 8. Authorize subcontractors to reduce technical content | 65  |
| 9. Authorize subcontractors to exceed cost or schedule  | 60  |
| 10. Contract change in schedule or cost                 | 57  |
| 11. Make versus buy                                     | 51  |
| 12. Select sources of supply for off-shelf items        | 51  |
| 13. Hire additional people                              | 51  |
| 14. Exceed personnel ceiling for crashing project       | 51  |
| 15. Bring subcontracted work in-house                   | 49  |
| 16. Select subcontractors                               | 43  |
| 17. Authorization to exceed company funding             | 8   |





any set of decisions. Thus, one cannot say that the possession of any one or any subset of these authorities by the project would characterize a project organization, or that their absence would indicate a functional organization.

Each laboratory manager was also asked to indicate how much of the work in his laboratory was organized along project lines. Eighteen said that 90 per cent or more of their effort was project organized. The other 19 indicated that less than 50 per cent of the laboratory's work was project organized. No relation is found between the laboratory manager's response and the index of project authority for the project that was studied in his laboratory. Also no relation is found between either of the success indexes and any or all of the authority questions.

The second index of the form of project organization is based on personnel reporting relations. Each of the project managers was asked to reply to three questions about all people working on his project:

1. To whom did they report for work assignments (project manager or functional manager)?

2. To whom did they report for merit reviews (project manager or functional manager)?

3. Were they physically located near the project manager or the functional manager?

The number and the percentage of professional and administrative personnel, both full-time on the project or part-time, were determined for all combinations of the three responses.



The results of these tallies show three distinct types of organization. In one type the reporting relationships and the location were predominantly with the project manager; this we have called project organization. In a second type responses to all three relations were predominantly with the functional manager; this we have called functional organization. In the third distinct type personnel reported to the project manager for work assignments, but were responsible to the functional manager for merit review and were physically located in his area; this we called matrix organization. It is a recognized and frequently described form of organization which is sometimes labeled project-functional or matrix-overlay. A particularly rich case study of this form of organization at Martin-Orlando is reported by Kennedy and Hansen (1965).

The classification into the three organization types was performed separately for professional personnel and for administrative personnel. The basis for classification was that more than 50 per cent of all personnel met the stated criteria for that type. Fortunately, and interestingly, there were no ambiguous or marginal instances. The number of projects classified in each type is shown in Table V. It should be specially noted that in some projects the professional personnel are organized in one way, the administrative personnel in another.

The frequency distribution of projects, from wholly functional work direction to wholly project work direction, is shown for professional personnel in Fig. 2, and for administrative personnel in Fig. 3. The



TABLE V  
Classification of Projects According  
to Type of Organization

| Professional Personnel | Administrative Personnel |        |            | Data<br>missing |
|------------------------|--------------------------|--------|------------|-----------------|
|                        | Project                  | Matrix | Functional |                 |
| Project                | 10                       | 1      | 1          | 3               |
| Matrix                 | 0                        | 2      | 1          | 1               |
| Functional             | 2                        | 1      | 10         | 1               |





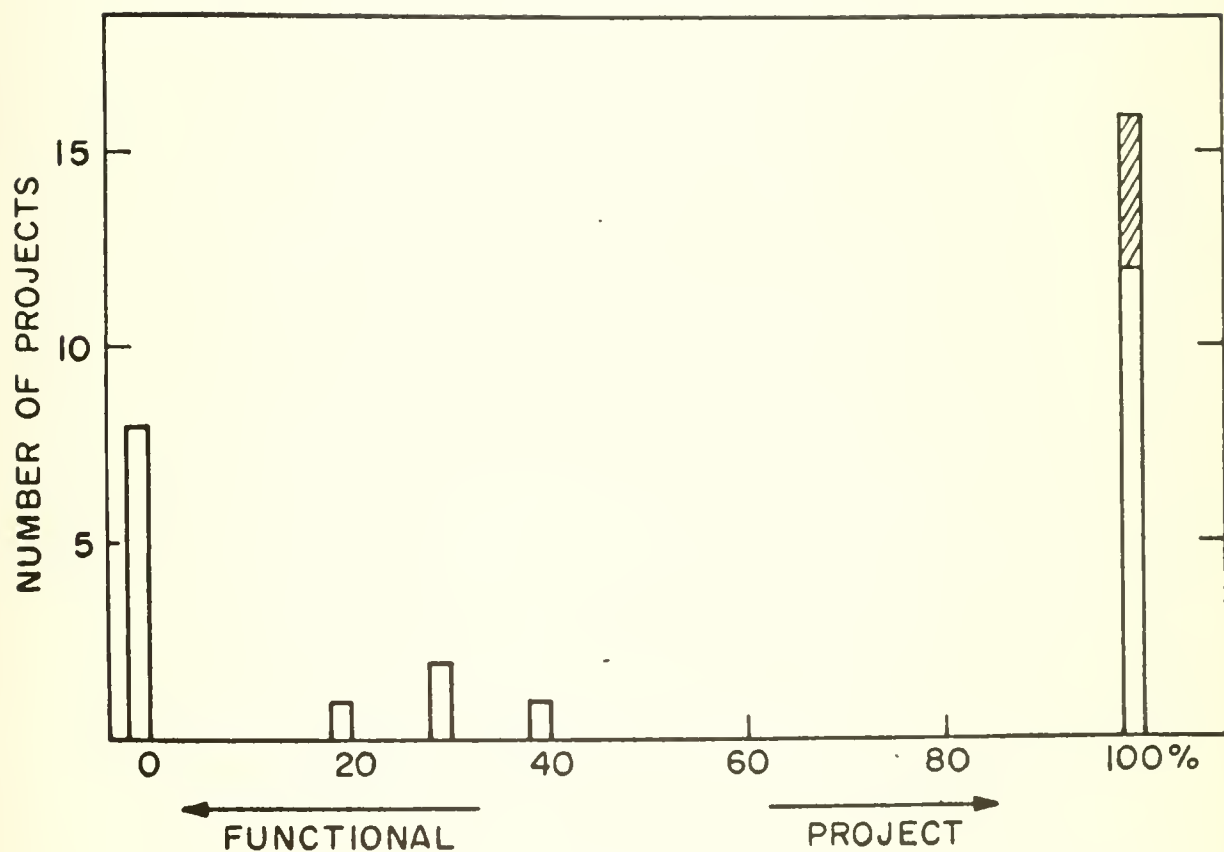


FIG. 2 PERCENT OF FULL-TIME ADMINISTRATIVE PERSONNEL REPORTING TO PROJECT MANAGER FOR WORK ASSIGNMENTS

MATRIX PROJECTS ARE REPRESENTED BY  
SHADDED PORTION OF BAR



PERSONNEL  
 100% TO 100%  
 100% TO 100%

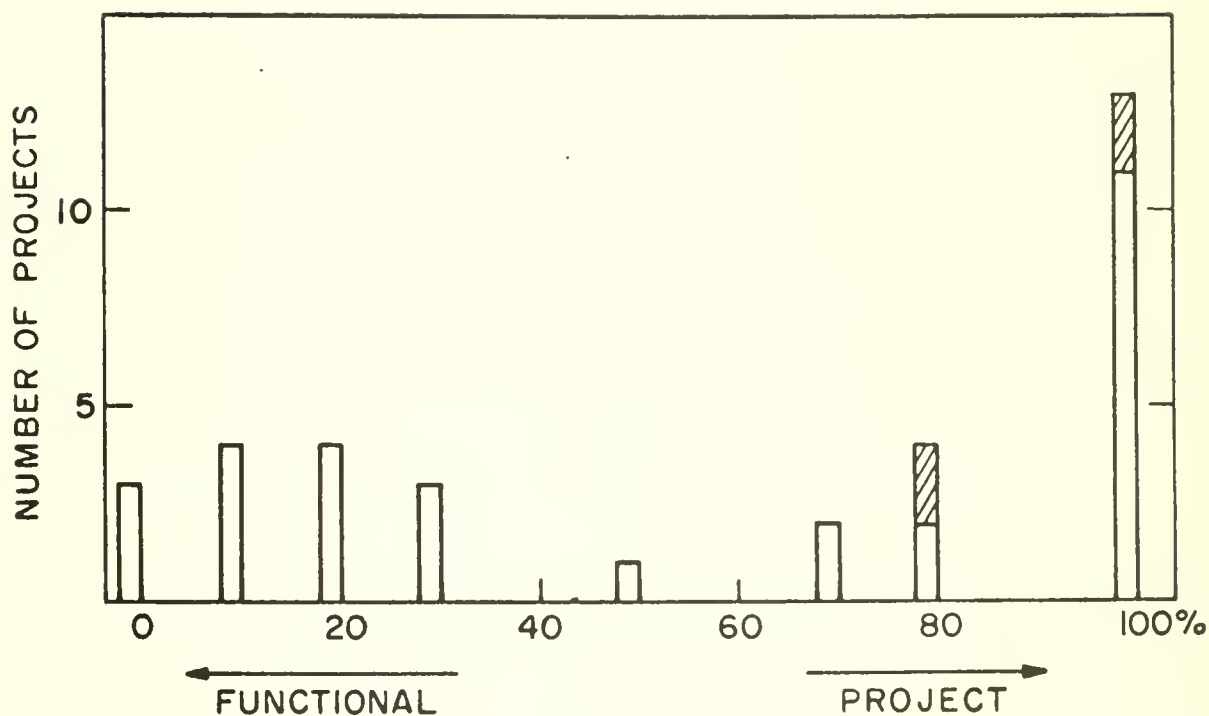


FIG. 3 PERCENT OF FULL-TIME PROFESSIONAL PERSONNEL REPORTING TO PROJECT MANAGER FOR WORK ASSIGNMENTS

MATRIX PROJECTS ARE REPRESENTED BY CROSS HATCHING



PERCENT OF PROJECTS IN EACH FUNCTIONAL CATEGORY

sample size in Figure 3 is smaller than in Figure 2 since some projects had no administrative personnel directly assigned to them. Also two projects in Figure 3 had no full-time administrative personnel but had several part-time people who worked on two or more projects.

It is of interest to inquire whether project authority is greater in one or another type of organization. The basic data are presented in Table VI. No clear pattern of relationships emerges, but there is a suggestion that, on the average, project authority is greater in the matrix organization of professional personnel than in either the pure project or pure functional organization. One might have expected that the matrix project would have lower authority as a consequence of the dual reporting relations. It may be that a more competent manager is put in charge of matrix projects (see Paca, 1964; Swanson, 1964).

#### Factors in Project Success

There remains only the simple task of relating our newly constructed measure of project organization with the two measures of project performance. The results are presented in Table VII. The only suggestive findings are (1) that projects in which administrative personnel report to the project manager rather than to a functional manager are less likely to have cost or schedule overruns, and (2) that functional organization, compared to project organization, of professional personnel results in higher rated technical success.



TABLE VI

Authorities of Project Manager in  
Different Types of Project Organization

| AUTHORITY  | <u>Administrative personnel</u> |     |      | <u>Professional personnel</u> |     |      |
|--|---------------------------------|-----|------|-------------------------------|-----|------|
|  | Project Matrix Functional       |     |      | Project Matrix Functional     |     |      |
|  | N=12                            | N=4 | N=12 | N=15                          | N=4 | N=14 |
| sign priorities                                      |                                 |     |      |                               |     |      |
| support areas  | 75%                             | 75% | 75%  | 80%                           | 75% | 71%  |
| relax performance requirements; e.g., omit tests     | 92                              | 75  | 67   | 80                            | 100 | 64   |
| authorization of total overtime budget               | 67                              | 100 | 67   | 80                            | 75  | 71   |
| contract change in technical scope                   | 92                              | 50  | 67   | 73                            | 75  | 64   |
| authorize subcontractors to reduce technical content | 75                              | 75  | 75   | 73                            | 75  | 64   |
| exceed cost or schedule on subcontracts              | 50                              | 75  | 83   | 53                            | 75  | 79   |
| contract change in schedule or cost                  | 67                              | 50  | 67   | 47                            | 50  | 71   |
| make vs. buy   | 58                              | 50  | 33   | 47                            | 100 | 43   |
| select sources of supply for off-shelf items         | 83                              | 25  | 42   | 67                            | 50  | 50   |
| hire additional people                               | 67                              | 50  | 25   | 60                            | 100 | 36   |
| exceed personnel ceiling                             | 33                              | 75  | 42   | 27                            | 75  | 57   |
| bring subcontracted work in-house                    | 58                              | 50  | 50   | 40                            | 100 | 50   |
| select subcontractors                                | 67                              | 50  | 33   | 53                            | 100 | 29   |
| AVERAGE  | 68                              | 61  | 56   | 55                            | 87  | 58   |





TABLE VII

Two Measures of Success of Projects  
With Different Types of Organization

|   | <u>Administrative Personnel</u> |     |            | <u>Professional Personnel</u> |     |            |
|---|---------------------------------|-----|------------|-------------------------------|-----|------------|
|   | Project Matrix                  |     | Functional | Project Matrix                |     | Functional |
|   | N=12                            | N=4 | N=12       | N=15                          | N=4 | N=14       |
| Percent of projects<br>rated highly success-<br>ful technically | 33                              | 25  | 42         | 20                            | 0   | 57         |
| Mean technical success<br>rating (1 is highest)                 | 3.5                             | 3.8 | 3.2        | 4.0                           | 4.6 | 2.8        |
| Percent of projects<br>without cost or<br>schedule overruns     | 42                              | 25  | 25         | 33                            | 50  | 36         |



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